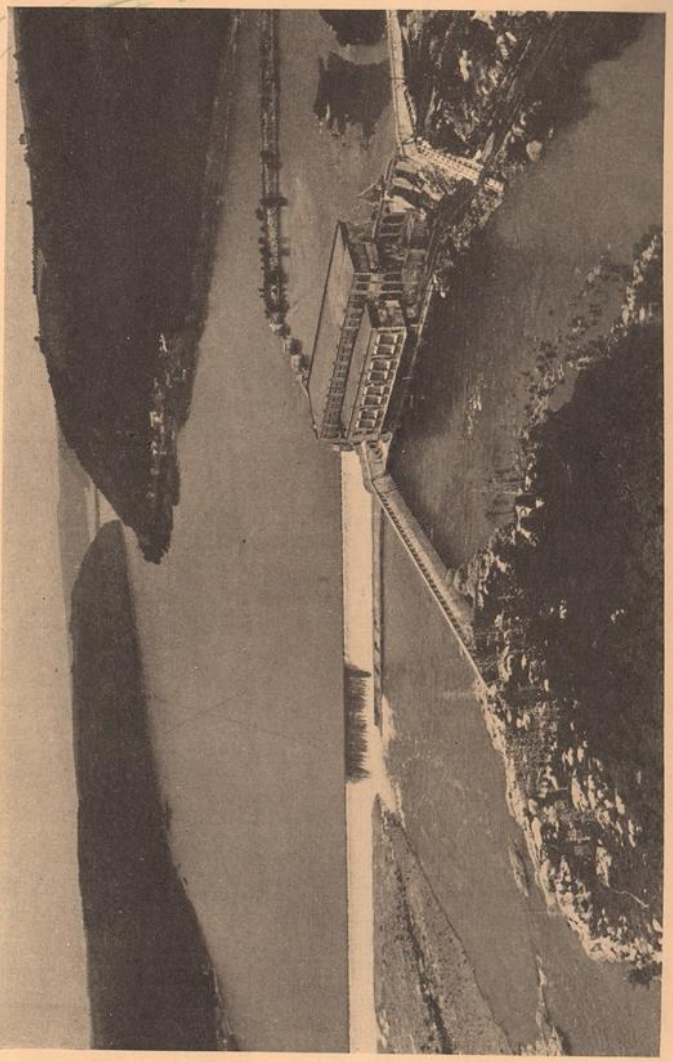
HOLTWOOD POWER DEVELOPMENT

Presented to—
Anna Mary Murr as
a souvenir from Holtwood
June 17 1923.

Holtwood Power Development

Pennsylvania Water and Power Company



AIRPLANE VIEW OF HOLTWOOD POWER DEVELOPMENT

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PENNSYLVANIA WATER & POWER COMPANY

OFFICERS

Chas. E. F. Clarke . . . . . President
J. A. Walls . . . . . Vice-Pres. and Chief Engineer
James L. Rintoul . . . . . Treasurer
F. J. Allen . . . . . Secretary

BOARD OF DIRECTORS

J. E. Aldred, Chairman

Wm. M. Barnum . . . . . New York
A. C. Bedford . . . . . New York
Mortimer N. Buckner . . . . . New York
F. D. Carney . . . . . Steelton
Josiah B. Chase . . . . . Boston
Chas. E. F. Clarke . . . . . New York
A. V. Davis . . . . . Pittsburgh
H. J. Fuller . . . . . New York
Rodman E. Griscom . . . . . Philadelphia
Joseph W. Gross . . . . . Philadelphia
Sir Herbert S. Holt . . . . . Montreal
S. Ray Marshall . . . . . London
R. M. Smith . . . . . New York
J. A. Walls . . . . . Lewisburg

EXECUTIVE COMMITTEE

J. E. Aldred, Chairman

Wm. M. Barnum — Mortimer N. Buckner
A. C. Bedford — Chas. E. F. Clarke

FOREWORD

TO OUR VISITORS AND NEIGHBORS:

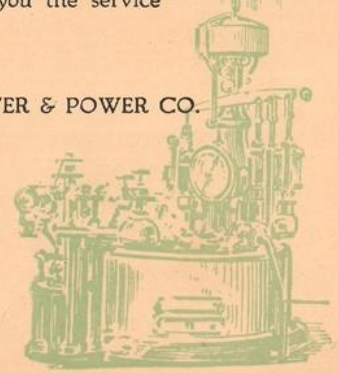
We have prepared this souvenir booklet to point out some of the interesting features of the Holtwood Power Development; to explain to the non-technical reader a few of the basic principles underlying the development of water power, concerning which there seems to be considerable misunderstanding; to express our appreciation of the interest shown in our plant by those who have visited it, and to furnish an incentive to others to visit Holtwood.

We realize that the majority of our visitors are residents of Lancaster and York Counties. We would ask them to remember that our development is located in and is an important part of "The Garden Spot of America" and should have a place in their pride, just as we are proud to have played a part in the growth of this famous region.

Our plant is open for inspection at all times, and we will gladly make every effort to demonstrate to you the service we are endeavoring to render.

PENNSYLVANIA WATER & POWER CO.

Holtwood, Pa., 1922.



USEFUL INFORMATION FOR VISITORS

A guide to show visitors through the plant may always be found at the company's property office, near the outer entrance to the power house.

The Power Company has built an attractive club house for its employees. On the first floor will be found lavatories for men and women, a pool and billiard room, the Holtwood Post Office, and a refreshment stand where the Holtwood Amusement Company sells post-cards, ice cream, candy, cigars and tobacco, kodak films, etc. Visitors are welcome to use these facilities.

The second floor of the club house, containing a reading room and ball room, is ordinarily reserved for members and their guests, but may be inspected by visitors accompanied by a member or guide. Moving picture exhibitions and dances are frequently held in the club house.

Meals and lodgings may be had at the company boarding house upon application to the local agent.

Road maps showing the best automobile routes to Holtwood will be found inserted inside the back cover.

Holtwood is located on the Columbia and Port Deposit branch of the Pennsylvania Railroad, which follows the Susquehanna River from Perryville, Md. (on the main Philadelphia-Baltimore line) to Columbia, Pa. The condensed schedule of trains as of September, 1922, is as follows:

NORTH-BOUND

	Week-Days		Sundays	
Leave Perryville	9:05 A.M.	3:45 P.M.	9:05 A.M.	4:15 P.M.
Arrive Conowingo	9:38	4:17	9:38	4:43
" **Holtwood**	10:08	4:54	10:08	5:21
" Pequea	10:19	5:05	10:19	5:33
" Columbia	10:55	5:42	10:55	6:10

SOUTH-BOUND

	Week-Days		Sundays	
Leave Columbia	8:05 A.M.	3:55 P.M.	8:05 A.M.	3:50 P.M.
Arrive Pequea	8:40	4:32	8:40	4:25
" **Holtwood**	8:51	4:43	8:51	4:39
" Conowingo	9:20	5:15	9:20	5:25
" Perryville	9:55	5:45	9:55	6:00

INTERESTING FACTS ABOUT THE HOLTWOOD DEVELOPMENT

This famous Lancaster County water power plant develops about 110,000 electrical horsepower.

Several times as much power as this is still going to waste in the remaining portion of the river between Columbia and Perryville because men are not willing to put up their money to develop it.

The water power developed here results in a saving of about 3,000,000 pounds of coal per day.

Electricity is sent 40 miles to Baltimore and 15 miles to Lancaster, at 70,000 volts, over aluminum and copper cables of a total length of 570 miles.

Owing to lack of storage reservoirs, during times of flood there goes to waste over the dam from one million to three million horsepower.

150,000 cubic yards of rock were blasted from the tailrace.

The dam is 55 feet high and nearly half a mile long.

340,000 cubic yards of concrete were used in the dam and power house.

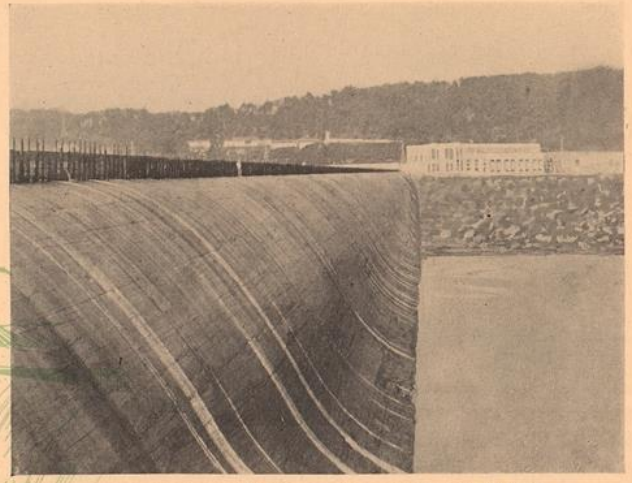
To transport the cement used would require a freight train twenty miles long.

A single bearing on one of the big turbines carries a weight of 234 tons, including the water thrust.

At full load more than 10,000,000 gallons of water per minute pass through the turbines.

In the five years 1917-1921 inclusive the average output of the Holtwood plant was 488,856,000 kilowatt-hours, or about 655,000,000 horse-power-hours, per year. This is greater than the output of any other single water power plant in the country east of the Mississippi River and south of Niagara.

DAM AND POWER HOUSE FROM YORK COUNTY SHORE, WITH FLOOD PASSING OVER THE DAM



SAME VIEW WITH FLASH BOARDS ON CREST OF DAM

HYDRO-ELECTRIC POWER

NATURE OF WATER POWER

Everyone realizes in a general way that there is **power** in falling water. But most persons are very hazy as to the real nature and underlying principles of water power. In their minds it is associated with the spectacular rush and roar of what is commonly called a "waterfall," as for example Niagara Falls. As they stand outside the Holtwood power house and see the calm water in the forebay above the power house and the gently surging water in the tailrace below, they see no evidence of tremendous forces and cannot realize that the power of 110,000 horses is harnessed at this point.

Two things are essential for the development of hydraulic power—a supply of water, and a difference in height or elevation which causes the water to flow from one level to another. In simple language, the more water there is, and the farther it drops, the greater is the power. The amount of the drop, or in other words the vertical distance from the upper level to the lower level, is usually called the "head." The relation between these quantities is shown by the fact that theoretically one cubic foot of water per second falling through a vertical distance of 8.8 feet produces one horse-power.

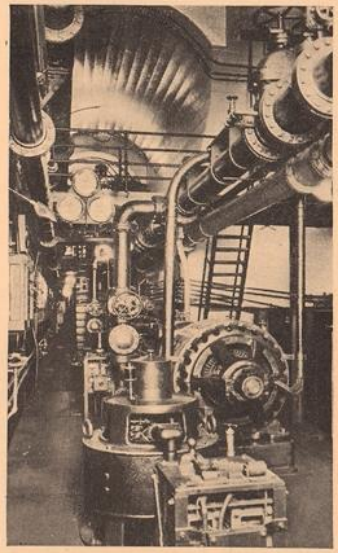
REASONS FOR BUILDING A DAM

In a few favored places such as Niagara Falls nature has provided a fall or drop concentrated at one point. More frequently the drop is spread over a considerable length of the sloping course of a stream in the form of rapids. The first means that man employed to utilize the power of such a swiftly running stream was the current wheel. It is a sort of paddle wheel supported over a stream so that the paddles dip into the water and move with the current. To utilize even a small part of the total power of a stream in this fashion would require a long series of these clumsy wheels stretching along the whole length of the rapids. By building a dam at the foot of a rapid the drop can be concentrated at one point. For

example, above Holtwood before the dam was built the river dropped over 50 feet in seven miles. By building a dam the engineers formed a practically level lake and obtained a fall or head of over 50 feet at Holtwood. The dam also serves to divert the water, or part of it, to the power house from the main channel.

METHODS OF UTILIZING WATER POWER

In order to utilize such a water power in the most efficient manner, engineers and inventors have perfected great water wheels called turbines. In the case of the old style over-shot and under-shot water wheels which are familiar to every one who has visited old water-driven grist mills, one could see and understand the action of the wheel. In this new style plant the turbine is entirely hidden from view by masses of concrete. These passages formed in the concrete serve to lead the water into and through the turbines as smoothly as possible, as turbulence means loss of power.



VIEW IN PIPE TUNNEL

For the most part the favorable water power sites are many miles distant from cities where power is most needed. For many years this fact retarded the development of water power. Man had water wheels, but the only way he knew of using the power therefrom was to connect up the wheels with machinery by means of pulleys and gears, belts and chains, and shafting. Power cannot be transmitted far by these means. Even in transferring it from one end of a factory to the other a great deal of it is lost through friction.

In recent years engineering geniuses have perfected methods and apparatus for the generation and long distance transmission of electrical energy. Great generators are connected directly to the water wheels. The "voltage" or electrical pressure is then raised by "transformers" and the electricity is sent over the transmission lines to distant cities where the power is needed.

A "hydro-electric" plant, then, is a combination hydraulic and electric plant. The power of the falling water is changed into electrical power, which can be sent to the point where it is needed. Such a plant is that at Holtwood.

ENGINEERING FEATURES OF THE HOLTWOOD DEVELOPMENT

FACTS ABOUT THE SUSQUEHANNA

The Susquehanna River is the largest and most important stream flowing into the North Atlantic Ocean with the single exception of the St. Lawrence. Its drainage basin includes 27,400 square miles in the States of New York, Pennsylvania and Maryland. In the last forty miles of its trip to the Chesapeake Bay, from Columbia to tidewater, the river drops about 225 feet, giving an average slope of 5.6 feet per mile. Throughout this reach the river is walled in by steep rocky bluffs, at places separated by only a few hundred yards, and at other points over two miles apart.

BEGINNINGS OF THE HOLTWOOD DEVELOPMENT

Many years ago these conditions called the attention of water power investigators to the lower reaches of the Susquehanna. After years of preliminary work the McCall Ferry Power Company was finally organized, and actual construction work was started in 1905 at Holtwood, or McCalls Ferry, as it was then called. This company failed and ceased work in 1907. After some delay the Pennsylvania Water and Power Company was formed and brought the dam and the first section of the power house to completion. Commercial operation was begun in October, 1910.

GENERATOR ROOM

WIDE FLUCTUATIONS IN RIVER FLOW

The variable flow of the Susquehanna is worthy of note. The maximum flow is about 250 times the minimum flow. Each year there is a period of low water, lasting for months. During the low water period the flow may drop to one-fifteenth of the average flow of 40,600 cubic feet per second. The Pennsylvania Water and Power Company has shown how the river may be successfully developed notwithstanding such variability.

NATURAL POWER SITE AT HOLTWOOD

The Holtwood site was chosen for the power development because of its natural advantages. The steep bluffs which wall in the river above this point kept the area of flooded land at a minimum. A deep channel near the Lancaster County shore was utilized for the tailrace, and an island, nearly a mile long, made a natural wall separating this tailrace from the main river channel. Another island in the middle of the river somewhat reduced the amount of concrete necessary for the dam. A short distance above the dam there is a bend in the river which tends to throw the ice over toward the York County side, away from the power house.

FEATURES OF DESIGN AND CONSTRUCTION

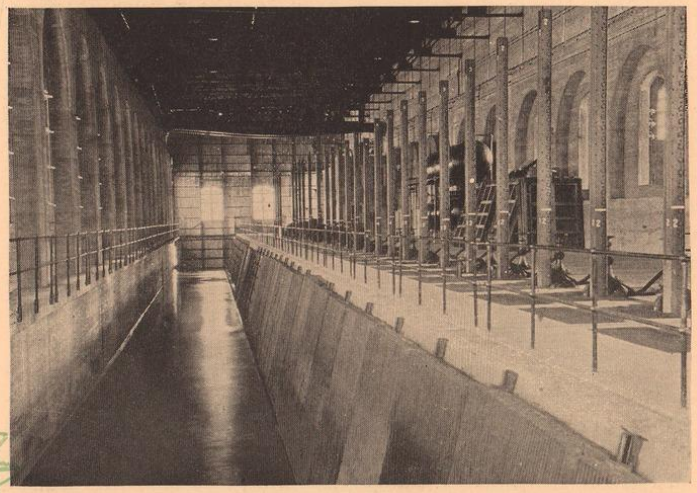
Before this site could be utilized twelve miles of the Columbia and Port Deposit Railroad had to be relocated higher up on the hill-side. In its old location the track would have been flooded for a distance of six miles above the dam, and in order to get back down to the old level below the dam without too steep a grade it was also necessary to raise six miles of track below Holtwood.

A temporary construction bridge of concrete, 50 feet wide and half a mile long, was built to carry the tracks on which the construction machinery operated. The concrete in the dam was placed by great pelican cranes traveling on this bridge.

The dam is nearly half a mile in length, is 65 feet wide at the base, and has an average height of 55 feet. It is

constructed of solid concrete, and is so heavy that neither flood nor ice can push it away. At the Lancaster County end of the dam is the power house, 500 feet long and 140 feet wide, in which are housed the water wheels, generators and other apparatus.

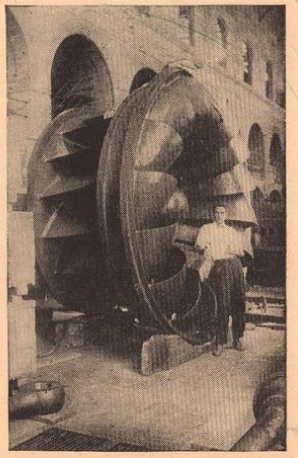
Above the power house is the "forebay," which is an open area of water surrounded by a ramp, concrete walls with submerged arches, and log booms. These are to keep out ice and other floating objects. From the forebay the water passes through another set of submerged arches in the power house wall into the gate house. Here, just as in any small water power grist mill, the water



VIEW IN GATE HOUSE SHOWING TRASH RACKS IN FRONT OF INTAKES

passes through screens which keep out floating trash, fish, etc., and then through gates which can be closed when it is necessary to repair the water wheels. The water then shoots down through big concrete tunnels into great concrete chambers called "wheel-pits," one for each water wheel. Each of these pits is big enough to contain a two-story house, 30 feet long, 30 feet wide and 30 feet high.

Once in the wheel pits, the water passes through a series of steel wicket gates, which form a great ring of spouts, into the water wheels or turbines. These are placed with the shafts vertical, instead of horizontal like most grist mill wheels. Here is illustrated one of these wheels. An idea of its size can be obtained by comparison with the height of the man. There are two of these wheels on every shaft with one exception.



STEEL WATER WHEEL READY TO BE LOWERED INTO PIT

After leaving the turbines the water passes through concrete tunnels called "draft tubes" into the tailrace, and then down the river.

About twenty-three tons of water falling through one of these turbines from the lake level to the tailrace, a height of 50 feet, will do the work of one horsepower for one hour. As some of the turbines are rated at 17,000 horsepower, the vast quantity of water required may be imagined.

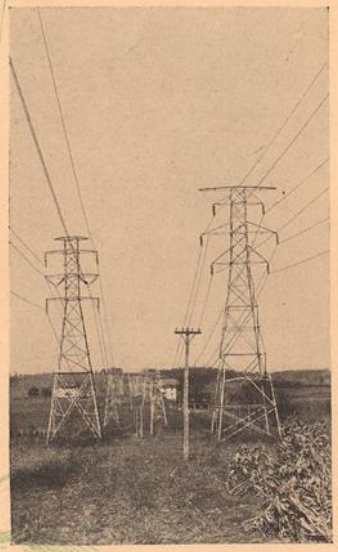
The vertical turbine shafts stick up through the power house floor, and on each shaft is mounted the revolving part of a generator. When this is driven by the turbine, or water wheel, it produces electricity. The whole combination of a turbine and generator is called a "unit." At present there are eight units, but provision has been made for two more.

PATH OF THE ELECTRIC CURRENT

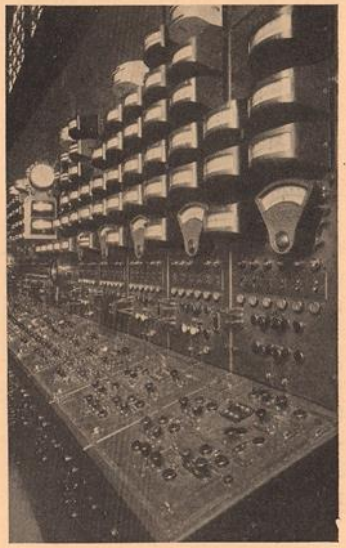
The generators produce current at a pressure of 11,000 volts. This is a high pressure, but the greater the pressure, the smaller will be the losses in transmission. So the electricity is conducted from the generators to "transformers" which raise the pressure to 70,000 volts. This increase in

voltage cuts down the losses in the transmission line to one-fourth of what they would be at 11,000 volts.

From the transformers the current passes through oil switches and other apparatus to Piney Island, and thence over the transmission lines to Baltimore and Lancaster. There are two tower lines to Baltimore, which is 40 miles away. The steel towers are about 65 feet high, and are spaced about 500 feet apart. The first span across the river is 1,800 feet long. The towers carry twelve stranded aluminum cables, over which the current passes. These are suspended from the crossarms by strings of porcelain insulators over three feet long. There is one line of towers to Lancaster carrying six copper cables.



HOLTWOOD-BALTIMORE TRANSMISSION LINE



CONTROL BOARD

OPERATION AND CONTROL OF GENERATING STATION

If you have visited the power house you probably noticed some attendants on a gallery overlooking the main floor, intently watching a lot of meters and pull-buttons and little red and green lights on black slate pan-

els. This is the switchboard from which the entire system is controlled. It may be compared to a switch tower in a big railroad yard. There are many different tracks or "circuits" of wire for the electricity to travel on. By simply pulling a button the operator can switch the current from one track to another. The little red and green lights show up a miniature copy of the system, indicating the tracks the electricity is traveling and which are alive. The meters show the voltage, current, and power. A mistake in switching by an operator might have any one of serious results that follow a railroad switchman's mistake. A generator might be wrecked, service to the distant cities cut off, and even lives might be lost. The operators who thus control 110,000 horsepower must be experienced men, carefully trained for their important work.

THE HOLTWOOD FISHWAYS

CAIL TYPE FISHWAY ON LANCASTER COUNTY SIDE

Two huge concrete fishways have been built by the Power Company to permit the passage of fish around the dam. The one on the Lancaster County side was constructed at the time the dam was built and was made in accordance with plans of the Department of Fisheries of the State of Pennsylvania, after much consultation with experts and examination of existing designs, and is of the improved Cail type. It is a solid concrete structure of a total length of approximately 350 ft., and forms a channel connecting the tailrace with the forebay. The fishway, contrary to certain rumors, was successful from the start and has recently been further improved at considerable expense. When the water is sufficiently clear, fish may sometimes actually be seen working their way up the fish ladder and passing out into the river above the dam.

Tests made by the United States Government in 1913 showed that all kinds of fish common to the Susquehanna were able to ascend this Lancaster County fishway, even as it was then built, excepting one species of fish only—

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ERRATUM

PAGE 16 LINE 2

ONE-FOURTH SHOULD READ ONE-FORTIETH

From the transfor
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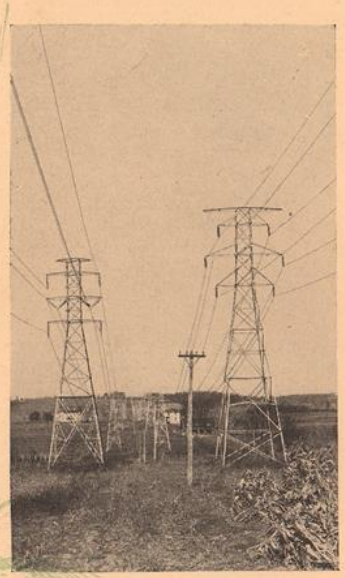
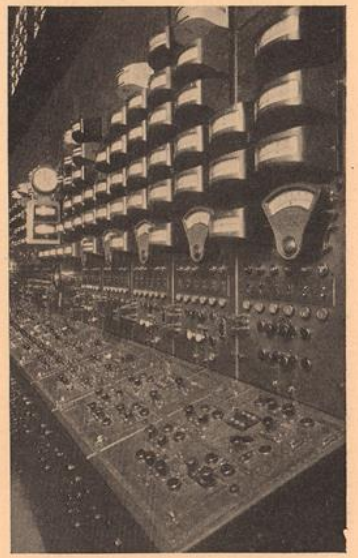


HOLTWOOD-BALTIMORE TRANSMISSION LINE



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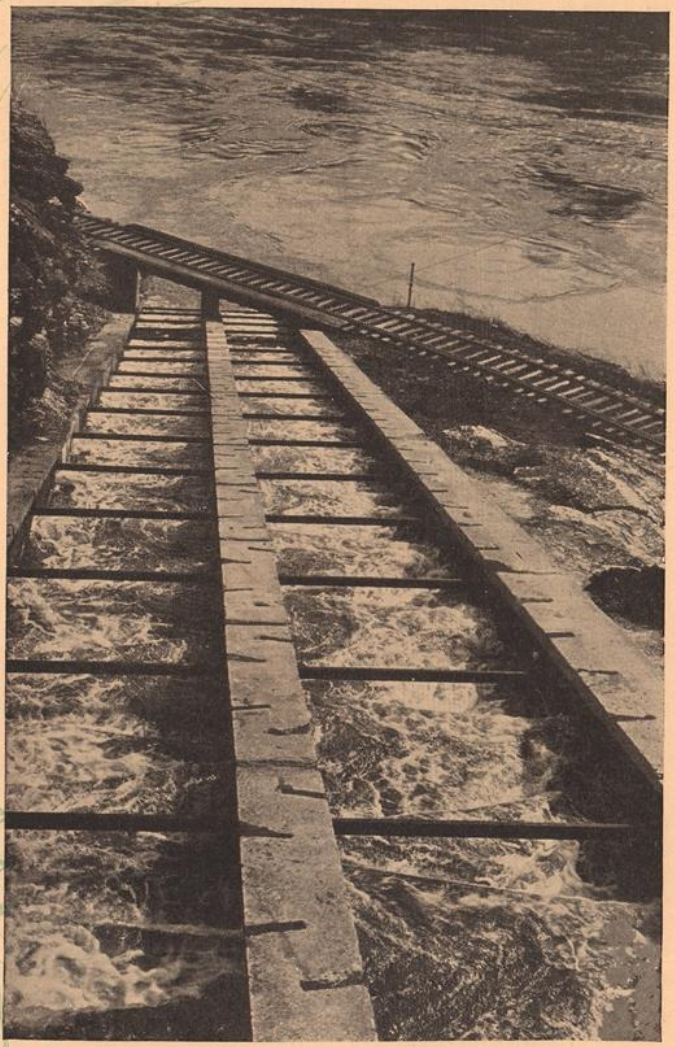


FISHWAY ON LANCASTER COUNTY SIDE

the shad. This latter fish comes in the Spring of the year up from the sea to the broad reaches of Chesapeake Bay. The bulk of the shad are caught there on the way to their spawning grounds by huge nets stretched across the bay. Only a small remnant of the whole migration escapes these nets and pursues its way up the Susquehanna and the other lesser streams flowing into the Bay.

GENERAL DECREASE IN SHAD CATCH

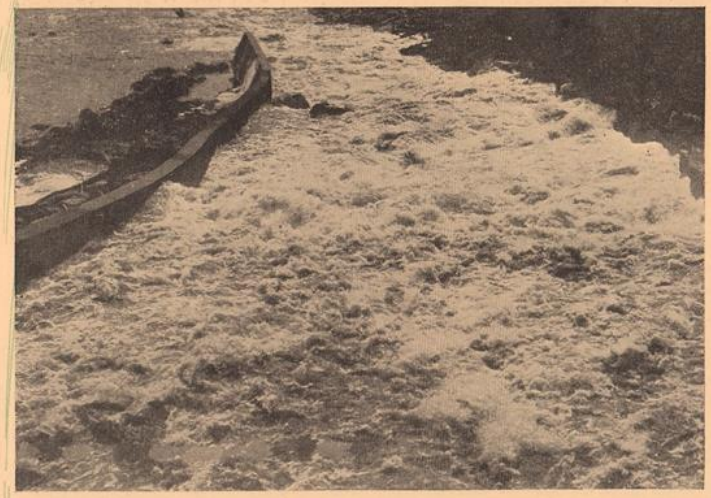
Due to the netting in the Chesapeake Bay and the increasing sewage and other pollution of the Susquehanna River, shad fishing has been steadily diminishing during the last few decades. This is true not only of the Susquehanna River, but of the other large rivers of the Atlantic Seaboard. Reports of the U. S. Bureau of Fisheries show that the catch of shad in Maryland decreased from 7,127,486 pounds in 1890 to 1,807,074 pounds in 1921.

YORK COUNTY FISHWAY BUILT LIKE NATURAL CHANNEL

Since it appeared that shad, on account of its timid nature, seemed to shun a fishway of the artificial ladder type, the Power Company later constructed, at great expense, a fishway designed by Mr. N. R. Buller, Commissioner of the Department of Fisheries of Pennsylvania, after much consultation and investigation both in this country and abroad. This fishway is from forty to fifty feet wide and 600 feet long, giving an easy slope from the main river channel below the dam to the pond level above the dam. It is constructed of concrete barriers and baffle walls, great boulders, and pools blasted out of the solid rock. The idea was to simulate the channel of a natural stream, with quiet pools and rapids, which might be attractive to the shad.

This fishway has been pronounced by experts to be the largest and most modern design of fishway in the world. It is located at the York County end of the dam, where it happens that the ice carried down by the river during the Spring "break-up" seems to be concentrated. As was anticipated at the time of the construction of the fishway, the heaviest battering action to which it is subjected by floods and ice occurs at its down-stream end.

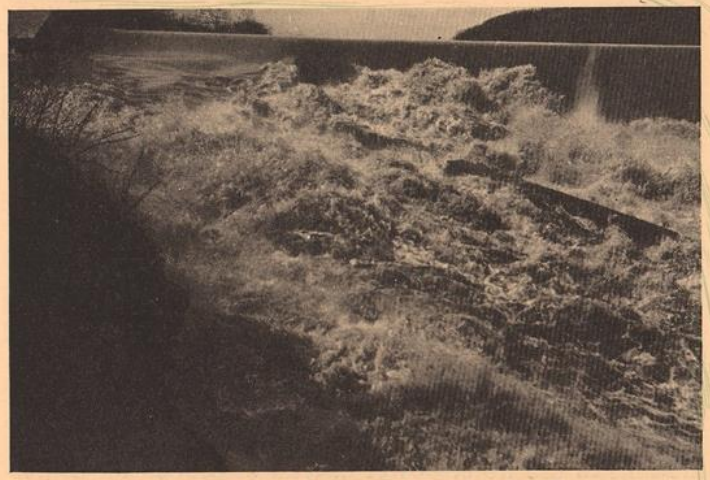
During ice floods the river carries ice floes 15 or more feet square and 10 to 15 feet thick, consisting of a cemented mass of packed ice from some up-river jam. Notwithstanding the most substantial manner in which this fishway was constructed, the battering effect of such great masses of ice and water rushing down such a chute, whose total vertical drop is 40 feet, is terrific. The effect is to tear out holes sometimes 50 feet in diameter and 10 feet deep from the mass of heavy boulders at the foot of the fishway. Since shad begin to ascend the river during the latter part of the Spring floods, there is no opportunity to repair such damage before the arrival of the shad.



THE YORK COUNTY FISHWAY MADE TO IMITATE A NATURAL STREAM

Year after year the Power Company spent large sums of money on the repairing and strengthening of this end of the fishway, only to have the work undone by the following Spring ice floods.

The Lancaster County fishway, not being in the direct path of that current of the river which carries the bulk of the ice, is not damaged by floods and continues its effectiveness as a fishway in passing those fish making their permanent home in the Susquehanna River.



THE YORK COUNTY FISHWAY DURING FRESHET

CONSERVATION OF NATURAL RESOURCES

REASONS FOR THE CONSERVATION MOVEMENT

Our great country was so richly endowed with natural resources, and is so vast in size, that we have been a wasteful nation. We have ruthlessly burned and cut down our forests, exhausted or greatly reduced the fertility of much of our soil by unscientific methods of agriculture, and used only the richest ores and mineral deposits, casting aside those which yielded only "low pay." This was only natural in view of the fact that there was little necessity for economy. But now that our population has become so great, and most of the land has been settled, we are finally awakening to the fact that our resources are not inexhaustible and that we must conserve and make the most efficient use of our wealth of land, timber, fuel, mineral deposits and waters. Farmers are using the methods of

"intensive cultivation," so long the salvation of crowded Europe. Miners are working the low-pay ores. The government is protecting the forest lands and encouraging scientific cutting of timber. This great movement for saving or wisely using what nature has given us is called "Conservation of Natural Resources."

CONSERVATION OF FUEL AND POWER

The World War gave new impetus to the conservation movement by calling attention to many kinds of waste, and particularly to the necessity for conserving fuel and power. There seems to be considerable difference of opinion among experts as to the extent of our coal deposits, but all are agreed that the readily available supplies of good quality are being exhausted at an alarming rate. Hence it is for the best interests of present and future generations to use water power instead of coal so far as possible.

WATER POWER MUCH MORE ECONOMICAL THAN STEAM

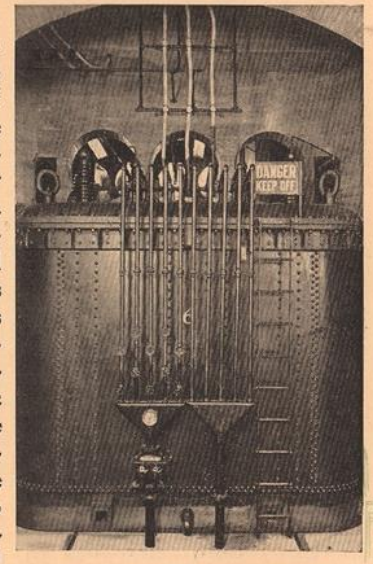
The process of obtaining power from coal is extremely wasteful. The coal, as such, is destroyed—lost forever. Furthermore the efficiency of developing mechanical power from coal is very poor. The average small steam power plant utilizes only about 5 per cent. of the heat energy in the coal. Even in the most modern steam-electric plant, operating under the best conditions, not more than 19 per cent. of the energy in the coal is delivered at the switchboard. A modern steam locomotive utilizes not more than 5 or 6 per cent. of the heat in the coal.

On the other hand, water power is very economical and efficient. The water is not changed or polluted by passing through the water wheels, and through nature's process of evaporation and rain it is returned from the ocean to the land, and is used over and over again. Also a modern water turbine is one of the most efficient machines known, and will deliver at the turbine shaft more than 90 per cent. of the theoretical power of the falling water.

PUBLIC INTEREST AROUSED

All these considerations have recently stimulated the public interest in water power development. The people are beginning to realize that true conservation of water power means its use. The United States Geological Survey has made an exhaustive study of the fuel and water power resources and load demand of the eastern industrial district, known as the "Super Power Report," which has been widely discussed.

HOLTWOOD PLANT AN EXAMPLE OF PRACTICAL CONSERVATION



70,000 VOLT TRANSFORMER

In the midst of this newly aroused interest the people of this section of the country may take great pride and satisfaction in the fact that they have a great hydro-electric project which was a pioneer of its kind, and which has, without serious mishap, for over ten years been delivering hydro-electric energy as a substitute for steam-electric energy, thus adding to the nation's wealth by conservation of coal. From the beginning of operation to the end of 1921 the Holtwood plant generated five and one-half billion horse-power hours, thus saving about four million tons of coal. The neighbors of the plant may well be proud that men had the vision, courage and resourcefulness to make this accomplishment possible.

REFORESTATION

IMPORTANCE OF FORESTS IN PENNSYLVANIA

No branch of the conservation movement concerns the people of Pennsylvania more vitally than forestry work —that is, the scientific use of what timber lands are left, the prevention of forest fires, and the replanting of waste lands for the production of lumber and the protection of water supply.

This great state was once a huge virgin forest. Its very name, "Penn's Woods," bears witness to this fact. Not so many decades ago Pennsylvania produced more lumber than any other state. Today, as the Honorable Gifford Pinchot has so forcibly pointed out, the state is

VIEW SHOWING GROWTH OF SEEDLINGS ON COMPANY'S LAND

practically deforested and is unable to supply more than one-fifth of the lumber needed by her people. The situation is the more serious because, to quote Mr. Pinchot, "No other natural resource comes closer to everyone, for wood enters into the production, manufacture and distribution of everything we eat, wear or use."

FORESTATION OF THE HOLTWOOD DEVELOPMENT PROPERTY

The Pennsylvania Water and Power Company, in acquiring its flooding rights, had to purchase hill properties along the river of a greater area than was actually required for flooding purposes. These lands were not well suited for agriculture, and the company recognized the fact that here was an opportunity to aid in a very real way the reforestation movement. Beginning in 1916, the company has carried on the forestation of these lands, following surveys and recommendations made by the Department of Forestry. Up to date, 160,000 seedlings have been planted, mostly pine and spruce, and additional plantings will be made from time to time. Arrangements have been made with men residing on or near the company's properties to be especially watchful for outbreak of fire, and in an emergency to employ sufficient help to extinguish the fire. The scientific cutting of the chestnut trees which were killed by blight, with proper protection of young growth, disposal of brush and slashings, and economic use of the timber, has also been carried on.

In doing this forestry work the company desires to aid the conservation movement, and also is furthering its own interests in that forestation gives a more uniform "run-off" or stream flow, and at some future time will yield, under proper forestry methods, a valuable crop of timber without again devastating the area.

RIVER COAL OPERATIONS

Another activity of the Pennsylvania Water and Power Company which is connected, at least indirectly, with conservation is the reclaiming of so-called river coal from the lake formed by the Holtwood dam. The Susquehanna River flows through the anthracite coal regions and receives the wash from mines and culm banks. Quantities of coal in a more or less finely divided state are carried down stream. The reservoir back of the Holtwood dam

AIRPLANE VIEW OF RIVER COAL DREDGING PLANT AT SHENKS FERRY

has acted as a settling basin and has accumulated a vast amount of this "river coal." The extent of the deposit is not accurately known, but probably amounts to a few million tons.

Arrangements have been made with a dredging company for the recovery of this coal. A modern hydraulic dredging and screening outfit has been installed at Shenks Ferry and operation on an extensive commercial scale is now in progress.

The recovery of this coal is equivalent to improving the efficiency of mining, as fuel which would otherwise be wasted is reclaimed.

The coal is being successfully used for steam power and heating purposes and a market is being steadily built up. Thus Lancaster County has acquired an important new industry and the opportunity to buy cheaper fuel, which means cheaper heat and power from that fuel.

ADVANTAGEOUS LOCATION OF THE HOLTWOOD PLANT

TREND TOWARD CENTRALIZATION OF POWER SUPPLY

There is a decided trend in the power field toward centralization and interconnection. Small central stations and private power plants are being shut down, and a constantly increasing part of the power requirements of each industrial district is being supplied by one or more huge central electric generating stations. These plants, with their great modern machines, up-to-date boiler and stoker equipment, and highly trained technical and business talent, can generate power far more efficiently than the small isolated plants. As a consequence city power companies have reached out into the surrounding country with their transmission and distribution lines, supplanting the old power plants in the nearby towns and villages. The next step which naturally followed was the interconnec-

tion of the systems of adjacent districts, but at first only on a small scale.

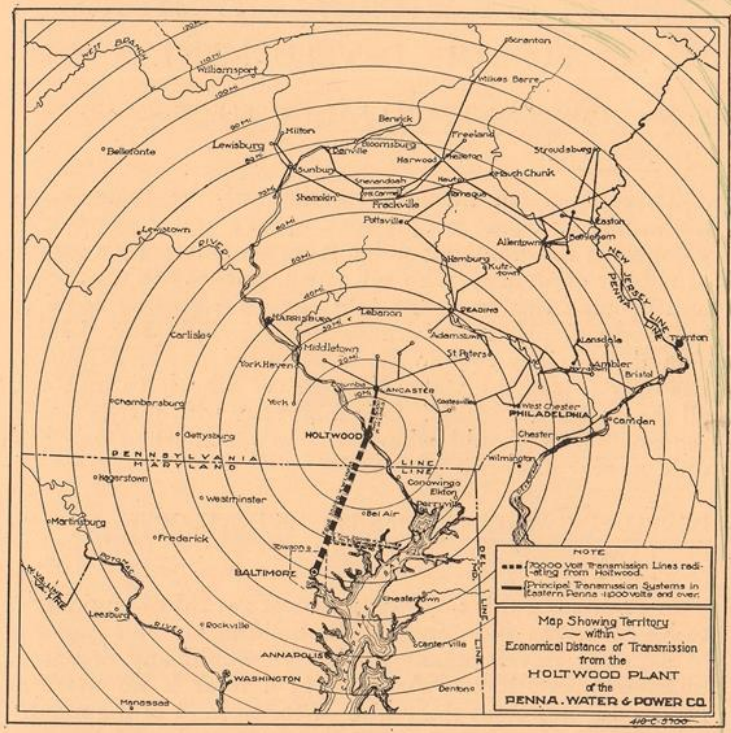
During the war the tremendous demand for power, coupled with the shortage of fuel and generating equipment, led the Government to make a survey of the various industrial districts, and it was found that large economies could be effected by building tie-lines of great capacity for the interchange of power between systems.

THE PROPOSED SUPER-POWER SYSTEM

The war ended before this work could be carried out. Mr. W. S. Murray then conceived the idea of a "Super-Power System," extending from Boston to Washington and inland for some 150 miles. Great "super-power" generating stations would be built at the coal mines and certain other favorable points and at available water-power sites, which, with the best of the existing stations, would supply all the power required in the zone. High voltage trunk lines, with branches to various load centers, would transmit the power. An exhaustive study of such a system was made by the U. S. Geological Survey, and it was shown that great savings of money, labor, and especially fuel would be accomplished thereby.

HOLTWOOD CENTRALLY LOCATED IN SUPER-POWER ZONE

It is probable that such a super-power system will be the result of gradual growth rather than of a single great reorganization and construction movement. Nevertheless power experts are agreed that increasing interconnection of systems is inevitable. The time when Eastern Pennsylvania will be covered by a vast interconnected network of electric power lines is not far distant. Such a system will be a great stimulus to water power development, as the combined system can absorb practically the entire output of the hydraulic plants, whereas when only one district is served by a large hydro station the plant is at times only partly loaded.



The accompanying map shows the strategic location of the Holtwood plant with respect to proposed interconnection. Within a radius of 80 miles (which is no longer unusual for electric transmission) are great load centers such as Philadelphia, Baltimore, Washington, Reading, Allentown, Trenton, Harrisburg, Lancaster, York, Wilmington, Bethlehem, Easton and a large part of the anthracite coal region. The present output of the electric utilities in this region is probably seven times the output of the Holtwood plant.

BUSINESS FEATURES OF A HYDRO-ELECTRIC DEVELOPMENT

COMMON MISCONCEPTION OF HYDRO-ELECTRIC INDUSTRY

There is much misunderstanding of the hydro-electric industry. Some people look upon a water power development as something stolen from the public by a group of robber capitalists, who sell stock, pocket the proceeds, and become rich from the sale of power costing nothing to produce. One sometimes hears people say, "Why should electricity cost so much when the power company has only to run the water through the wheels to turn out all the power it wants?" One might say with just as much reason, "Why should wheat cost so much when one has only to sow it, and it grows?"

DEVELOPING WATER POWER IS LIKE DEVELOPING A FARM

In examining this question we must get rid of engineers' technical terms and consider the building up and running of a power development just as we would any ordinary business proposition. A rapid in a river is no more a power development than a bit of forest land in the mountains is a farm. In each case nature has done her part; men must do the rest. Both propositions must have work done upon them, or, as we say, be developed, in order to bring out the value.

In the case of the prospective farm, nature has provided the soil and has enriched it to a greater or less extent by decaying vegetable matter. She provides the sunlight, air, and rain. To make a farm out of such virgin land some pioneer, some enterprising fellow willing to work, first must acquire the ownership of the property, either from the government by doing work on the land and filing claims, or by purchasing the land from previous owners. Then he must cut down trees, clear the land of rocks, build roads and lanes and buildings, buy or rent

farm machinery, plow and till the land, and little by little, by hard labor, transform his plot of land into a farm that will yield a return for his work.

Similarly, in the case of water power nature has provided the sloping river bed, the flowing water, steep banks, and the setting for the power plant. Like the pioneer farmer, the pioneer financier and engineer must freely give of their resources and ingenuity, their brains and brawn, in order to take advantage of the waiting opportunity.

LARGE AMOUNT OF PRELIMINARY WORK NECESSARY

First a staff of experts must study the proposition. Careful surveys are made. The amount of available power is computed. The question of flooding of land is studied. The variable flow of the river must be carefully considered, and data for years back must be collected. The water storage facilities and necessary steam auxiliary plants must be determined. Property lines must be located and options secured on land. Plans must be drawn up and machinery designed. The available market for power must be studied and prospective customers interested.

Now up to this point there is absolutely nothing tangible in evidence. But men have lavishly spent both money and labor, and are entitled to a return on both.

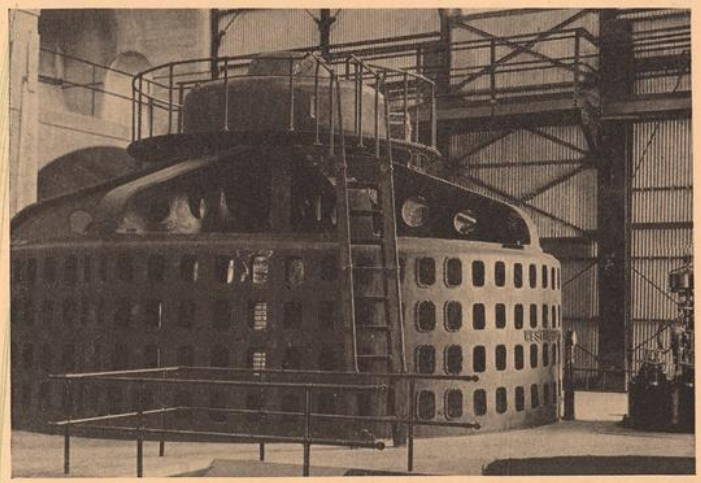
TANGIBLE CONSTRUCTION WORK

If all this preliminary work is successful, property must be acquired; roads and houses built; costly construction tools and machinery purchased, much of which cannot be used again; temporary bridges and coffer-dams constructed; the river diverted from the point where work is going on; vast quantities of rock excavated, and hundreds of thousands of cubic yards of concrete must be mixed and placed. All this having been accomplished, permanent machinery must be purchased and erected, and labor procured and trained. Rights-of-way must be acquired and transmission lines erected to cities and towns where the power is to be sold. Usually, as in the case of

Holtwood, the plant must be tied in with very large and expensive auxiliary steam plants in order to make good the deficiency of water power during low flow.

SKILL AND INDUSTRY IN OPERATION ALSO REQUIRED

But this is not all. Many a hydro-electric plant has failed to meet expenses after construction has been successfully completed, just as many farmers have failed after acquiring their farms.



16,000 HORSE-POWER GENERATOR

After a farm has been successfully started, the farmer cannot sit down and expect the rain and sun to do all his work. He must plow and fertilize, sow, cultivate and reap. He must work his farm, or no matter how good it may be, it will go to rack and ruin. He must have labor. He must contend with storms, dry seasons and wet seasons. He must buy, operate and keep in repair his farm machinery. He must have industry and intelligence. He must exercise good judgment in buying and selling and in finding the best market for his products. He may fail because he has so exhausted his resources that he does not have enough funds to tide his business over until the

farm begins to yield a return. All his efforts may be set at naught by some unpreventable disaster such as fire, storm, flood or sudden business depression.

BOTH PRODUCERS ENTITLED TO A FAIR PROFIT

All these statements may be applied to the power company as well as to the farmer. Both utilize natural resources; one uses the soil, air, sunlight and rain; the other, falling water. Both are entitled to a fair return on their initiative, foresight, judgment, perseverance and skill, as well as on their expenditures of money, time and effort. Both are entitled to insurance against risk. The farmer cannot give away his wheat; neither can the power company give away its electricity.

THE EVIL OF UNWISE INTERFERENCE

Unwise and antagonistic legislation serves only to deter water power development, making it more expensive and in the end increasing the cost of power to the consumer. The farmer, harassed by his neighbors and compelled to spend his time in law courts, neglects his farm. Both the power company and the farmer must be sufficiently unhampered in the conduct of their property and free from interference as to ownership for a reasonable length of time to make it worth their while to put their property into best condition and keep it so, for neither a short-term tenant farmer, nor a water power company frequently and unjustly assailed, may be expected to be able to produce to the best advantage and improve and maintain their properties adequately.

METHODS OF RAISING MONEY

Sometimes a farmer does not have money enough to pay for his farm outright and borrows money on a mortgage. In determining his profits, the interest on the mortgage is just as much a part of his expenses as the wages of his men. This is exactly the situation of the power company. The difference is that the farmer can often avoid a mortgage, whereas a power company cannot escape it.

The power company has to buy hundreds of thousands of cubic yards of concrete, and millions of pounds of machinery, costing millions of dollars. The only way to secure this money is to borrow it from people who have money to invest. The mortgages given to these people are called bonds.

The main difference between developing a farm and developing a water power is that in the latter a number of men get together to do by co-operation a thing which is too large to be done by one man. While a farm may have one owner, a power development, being so much larger, has many owners. To show that they are owners they receive shares of stock. A stock-holder is an owner, while a bond-holder is one who has loaned money on a mortgage.

DIFFICULTIES IN EARLY STAGES OF WATER POWER DEVELOPMENT

Expensive preliminary studies have been made in this country for a great many water power projects, which have then been abandoned; other companies have failed during construction; others have weathered construction difficulties, but have failed in operation; others have succeeded, and have made a reasonable profit, usually after a period of several years of no return to the stockholder on his investment. This is illustrated by the history of the Holtwood development, for no dividends were paid until 1914, nine years after construction work had been begun by the unsuccessful original McCall Ferry Power Company. Its successor, the Pennsylvania Water and Power Company, has conducted its operations with ability and with benefit to the territory which it supplies with power, and considers that it is entitled to a fair return on its capital, which by the 1921 report of the Power Company is shown to consist of an outstanding bonded indebtedness (corresponding to the farmer's mortgage) of $10,724,000 and capital stock (representing the money of the owners) of a par value of $8,495,000.

COST OF PRODUCTION NOT THE ONLY CONSIDERATION

The Pennsylvania Water & Power Company is strictly in the wholesale business, selling electrical energy to distributing companies in a form not suitable for direct use by small consumers. These latter companies must bear the heavy cost of transforming, distributing and retailing the power, and the small consumer should remember that the cost of generation of power is only a minor part of the cost of the service rendered to him by the distributing company. The low price of water power is often dwelt upon and is, naturally, of great importance to the consumer in establishing and building up his business in competition with similar businesses in other cities, but cheap power is only a lesser one of the very many advantages to the community that may be gained through water power service.

BACHELORS' QUARTERS

BENEFITS OF THE HOLTWOOD DEVELOPMENT TO THE COMMUNITY

We have seen that the Holtwood plant is a triumph of engineering skill—a pioneer accomplishment of man in his efforts to harness our great rivers—of which its neighbors may well be proud. We have also seen that the plant has enriched the nation by saving millions of tons of coal. But local visitors may still ask, "What tangible benefits has the plant brought to the community?"

DIRECT BENEFITS

The county and city of Lancaster have largely profited by the presence of this plant—directly because the plant is itself a great industry, and indirectly because it has attracted many other industries to Lancaster.

Many millions of dollars have been spent on this project. It has taken years to build the plant. At times over one thousand men were employed on construction work. A small village has grown up around the plant. Much of the pay of these people and the expenditures of the company has gone to the merchants, manufacturers and farmers of Lancaster County.

From the beginning of service to Lancaster in 1913 to the end of 1921 the Holtwood plant delivered at Lancaster over 500,000,000 horsepower-hours of electrical energy. Several hundred thousand tons of coal would have been burned to generate the same electricity by steam. The nation's rapidly dwindling fuel resources are larger by that much, and Lancaster is so much cleaner—for it must be remembered that the smoke and soot from that coal would have been discharged into the Lancaster atmosphere. There would have been thousands of tons of ashes to dispose of. Scores of men were released from labor in steam plants at a time when Uncle Sam needed every man. The coal saved represents many thousands of car loads. These cars were released for other work at a time of serious shortage. The labor of hundreds of men in mining and transporting the coal was saved.

During the four years 1917 to 1920—a period of war, readjustment, political and industrial confusion and unrest, strikes, labor shortage, and high prices—Lancaster had a very unique advantage—**unlimited power at prewar prices.** In other cities manufacturers emptied their bunkers, vainly searched for coal, and then turned to the central electric stations for help. The central station men in turn scraped their storage yards, burned screenings and coke breeze, frantically sought for coal at any price, and in many cases ended by curtailing their customers' supply. Such curtailment amounted to as much as 60,000 horsepower. In many more cities the power companies had to refuse to take on new business, partly on account of scarcity of fuel and materials and partly because of their inability to raise the necessary capital for extensions.

The power rates in Lancaster have been very low as compared with most cities which depend on steam generation. To meet the higher prices paid for coal, public service commissions were compelled to grant large increases in rates, sometimes in the form of surcharges proportioned to the cost of coal. In some cases these increases have amounted to nearly as much as the entire rate to large customers in Lancaster.

INDIRECT BENEFITS

But perhaps the most noteworthy benefit of water power to Lancaster has been its effect on the industrial prosperity of the community. A supply of hydro-electric energy attracts new industries which use power, for the manufacturer who buys electricity generated by water power not only reduces his power bill and is made independent of mine and railroad strikes and coal and car shortages, but is enabled to use for plant extensions capital which would otherwise be put into steam power equipment. Every new business so gained creates a demand for more labor and more raw materials. This results in greater population; increased trade; greater demand for food stuffs; more local building operations; greater real estate values; more money spent in the community, and so more banking business; more railroad shipments of raw materials and manufactured products, paying high-

class freight rates. Thus the benefit to the community is far greater than the mere value of the water power itself, and the advantages accruing from such power expand in an ever increasing progression.

GROWTH OF LANCASTER'S ELECTRIC LOAD

The result of the above mentioned conditions has been that the use of electric power in Lancaster has grown by leaps and bounds, surpassing all estimates. In competition with other cities Lancaster has been able to attract stable industries looking for reliable and abundant power. Even in 1921, when business depression caused a decrease in consumption of electrical energy in most cities, Lancaster's load was greater than in 1920.

INCREASED COST OF SERVING LANCASTER

In 1912, the year before hydro-electric service to Lancaster began, the city's total central station electric load was about 24,920,000 kilowatt-hours. In 1922 the total will be from three and one-half to four times as great. During this time the cost of coal doubled. Costs of labor and supplies soared. On account of low water and increased demand, the Pennsylvania Water and Power Company has had to secure by steam generation in Baltimore at high expense a steadily increasing proportion of the energy delivered to Lancaster. Yet during this period no portion of the increased cost was passed along to the Lancaster consumer. It is naturally to be expected that this extremely favored position as to rates will be somewhat modified and that a part of the increased cost will be borne by the consumers.

SUMMARY OF BENEFITS

Summing up, the Holtwood power development has brought this part of Pennsylvania an engineering marvel which excites the pride of neighbors and the admiration of visitors; the dam has formed a lake with wooded shores which adds to the already famed beauty of the "Garden Spot of America"; as a conservator of labor and fuel the plant has safe-guarded the resources of the community

and the whole nation; as a large business concern the plant has added to the country's wealth; as a preventive of noise, smoke and soot, water power is changing for the better the living and particularly the working conditions of the people; as a source of cheap, reliable, abundant power the plant has fostered the industrial growth and prosperity of Lancaster and the comfort of the people.

THE WATER POWER SITUATION IN PENNSYLVANIA

IMPORTANCE OF USING WATER POWER IN PENNSYLVANIA

Pennsylvania has been richly endowed with the four great natural resources—land, forests, minerals and water. To these the great wealth of the state may be directly traced, and on these the economic future of the state must depend. No other section of the country would suffer more severely from the exhaustion of its resources —a condition all too rapidly approaching in the case of forests, iron ore, coal, oil and natural gas.

CLUB HOUSE FOR EMPLOYEES, AND RAILROAD STATION

We have seen that true conservation means the maximum utilization of water for power, with the greatest possible efficiency and minimum waste. We have also seen what has been accomplished by one great Pennsylvania development, which should have been the fore-runner of other projects.

In view of these facts, Pennsylvania should be playing a leading part in developing water powers to the limit. The Commonwealth should encourage her citizens in every possible way to utilize the waters of the State to drive mills and factories, furnish heat and light, and add to the comfort and pleasure of the people.

What is the actual situation?

REASONS FOR LACK OF DEVELOPMENT

There is a great and growing demand for water power and we have heard much talk about water power projects, but in Pennsylvania no construction work of large magnitude is now actually under way. The chief reasons for this condition are (1) high construction costs and keen competition with steam power; (2) the extreme fluctuations in the flow of our streams; (3) the lack, in the past, of a constructive, consistent policy on the part of the state and uncertainty as to corporate rights, regulation and control.

1.—High Costs:

Among the so-called natural resources Pennsylvania is probably least favored as to water-power. The two requirements for such power have been pointed out—a supply of water, and a fall or "head". If the head is high, relatively little water is needed. In the far West heads are available running up into thousands of feet. In Pennsylvania there are no high heads available. Hence to get a large amount of power, vast quantities of water must be handled. In most cases massive dams must be built, heavy enough to withstand the assaults of the greatest floods. Ice condition are also severe.

Furthermore in Pennsylvania water power is somewhat in the position of "carrying coal to Newcastle." It must compete with coal in the home of coal. To be sure the

cost of fuel has increased greatly, but so have the costs of concrete, machinery and labor. The tremendous advances in steam engineering have made it very difficult for water power to hold its own, even if unhampered by governmental restrictions.

2.—Fluctuations in Stream Flow:

The supply of water in Pennsylvania is even more unsatisfactory for power purposes than the available heads. The total amount of water is ample, but its unequal distribution throughout the year or a series of years is a great handicap.

In an average year there falls on the State of Pennsylvania, in the form of rain and snow, enough water to cover the entire state to a depth of nearly 42 inches. Considerably more than half of this amount runs off in the various streams of the state and eventually finds its way to the sea. The rest is, for the most part, returned to the air by evaporation and transpiration. The amount of rainfall is practically beyond the control of man, but the "run-off" is influenced by the acts of man, and may be regulated—to some extent in total amount, and to a greater extent in distribution throughout the year.

The natural run-off of Pennsylvania streams is extremely variable, both from day to day or week to week and from season to season. At times of drought large streams dwindle to mere rivulets. At times of flood the streams overflow their banks and do great damage. For example, the maximum flow of the Susquehanna at Holtwood is 250 times the minimum.

Just as a chain is no stronger than its weakest link, the value of a water-power is determined largely by the minimum flow or by the "primary" or dependable year-round power. If a stream is developed only to this extent, the output is usually so small that the return on the investment is entirely inadequate. If additional machinery is installed to utilize secondary power, which would otherwise go to waste, the investment lies idle a large part of the time and duplicate steam capacity must be installed to supplement the water power.

This condition could be alleviated by the regulation of stream flow by means of storage reservoirs which impound flood water for release during times of low flow. Such storage projects would immediately stimulate hydro-electric development. They would also prevent or decrease flood damage. The Water Supply Commission of Pennsylvania has declared its belief that the same storage system could be used for both purposes. The co-operation of the state with the power interests in such stream flow regulation projects would be a great forward step in the interest of conservation and flood prevention.

3.—Governmental Policy:

As has been explained, the development of water power requires a large capital outlay before any returns on the investment can be had. The first cost of such hydro-electric developments as are possible in Pennsylvania, including transmission lines, substations and auxiliary steam plants, is on the average several times as great as the cost of a steam electric plant or plants to carry the same load.

In view of the inherently costly nature of water-power projects in Pennsylvania, individuals or corporations who are trying to develop such powers should be encouraged by the Commonwealth. To the inherent risk of the venture there should not be added hampering governmental restrictions and uncertainty as to corporate rights, regulation, life of franchise, etc.

UP-STREAM VIEW FROM PINNACLE ROCK IN 1920

Economically the development of water power is similar to any other business. If wheat raised in any particular locality cannot compete with wheat from the Middle West, then it will not be raised in that locality. If water power cannot compete on even terms with steam power, then water power will not be developed. Capital naturally flows into those channels which yield the greatest return. Mere discussion cannot change these economic laws. Theorizing on the desirability of conservation will not attract capital into this field and will not persuade people to invest their savings in water power securities. Assurance of an adequate return on the investment and stability as to future prospects are required.

NO EXCESSIVE PROFITS IN HYDRO-ELECTRIC INDUSTRY

There is no basis for the fear of unreasonable profits in hydro-electric development in Pennsylvania. Examina-

UP-STREAM VIEW FROM PINNACLE ROCK IN 1906 BEFORE DAM WAS BUILT

AIRPLANE VIEW OF HOLTWOOD DEVELOPMENT

tion of its history will show that the largest projects in the state have passed through an initial stage of failure and reorganization, or have paid no dividends, or in some cases never reached the operating stage. After a hydro-electric company has passed through the preliminary stages, however, and is on a profitable operating basis, it occupies a peculiarly stable position, and its securities are very attractive to the conservative investor.

FINANCIAL STABILITY OF THE PENNSYLVANIA WATER & POWER COMPANY

CONSERVATIVE POLICY OF THE POWER COMPANY

The history of the Pennsylvania Water and Power Company illustrates the necessity of making a careful study of economic factors before selecting a water power site. The strategic location of the Holtwood plant with respect to important industrial centers has been pointed out. Engineering and construction features have been described. The best proof of the high quality of the work is the plant's immunity from damage by storms, floods and ice. The same conservative and careful engineering skill and study have been given to the details of operation as to design and construction.

Beginning commercial operation in a small way in 1910, the company has gradually increased the plant capacity and transmission facilities to suit the needs of the load, but only after careful investigation has shown that the extension was economically justified.

RESERVE FUNDS

The widely varying flow of the Susquehanna has been mentioned. In the case of a hydro-electric development on such a stream, after the market has been developed the output will depend to a considerable extent on the river flow, over which the power company has no control.

ICEBERG AND FLOATING CAKE ICE IN LAKE ABOVE DAM

The Pennsylvania Water and Power Company has evolved the ingenious expedient of building up out of earnings a low flow "contingency reserve" or equalizing fund of over one million dollars, to smooth out the corresponding fluctuations in earnings and especially to guard against a reduction in revenue in case of the occurrence of a cycle of dry years.

The company has also set aside a depreciation reserve of nearly one million dollars for renewals and replacements when they become necessary, and as required by its mortgage deed of trust has set aside $75,000 a year (after 1924, $100,000 a year) into a sinking fund for the gradual payment of bonded indebtedness.

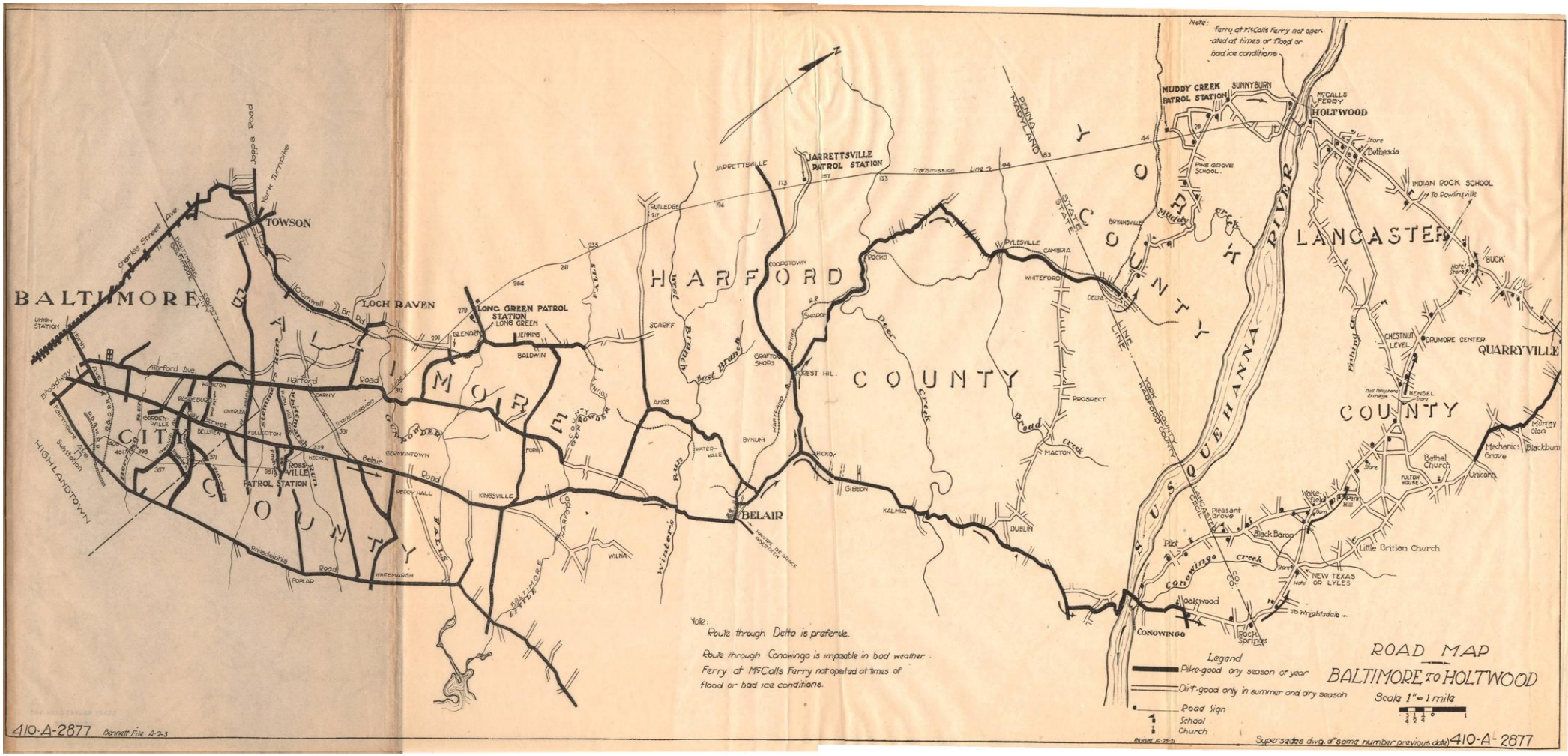
FUTURE SUCCESS ASSURED BY PAST RECORD AND PRESENT POSITION

The successful development, financially and technically speaking, of power on a river like the Susquehanna requires experience, acumen, knowledge and keen judgment. In twelve years of operation the Pennsylvania Water and Power Company has demonstrated the nature of such problems and has proved its ability successfully

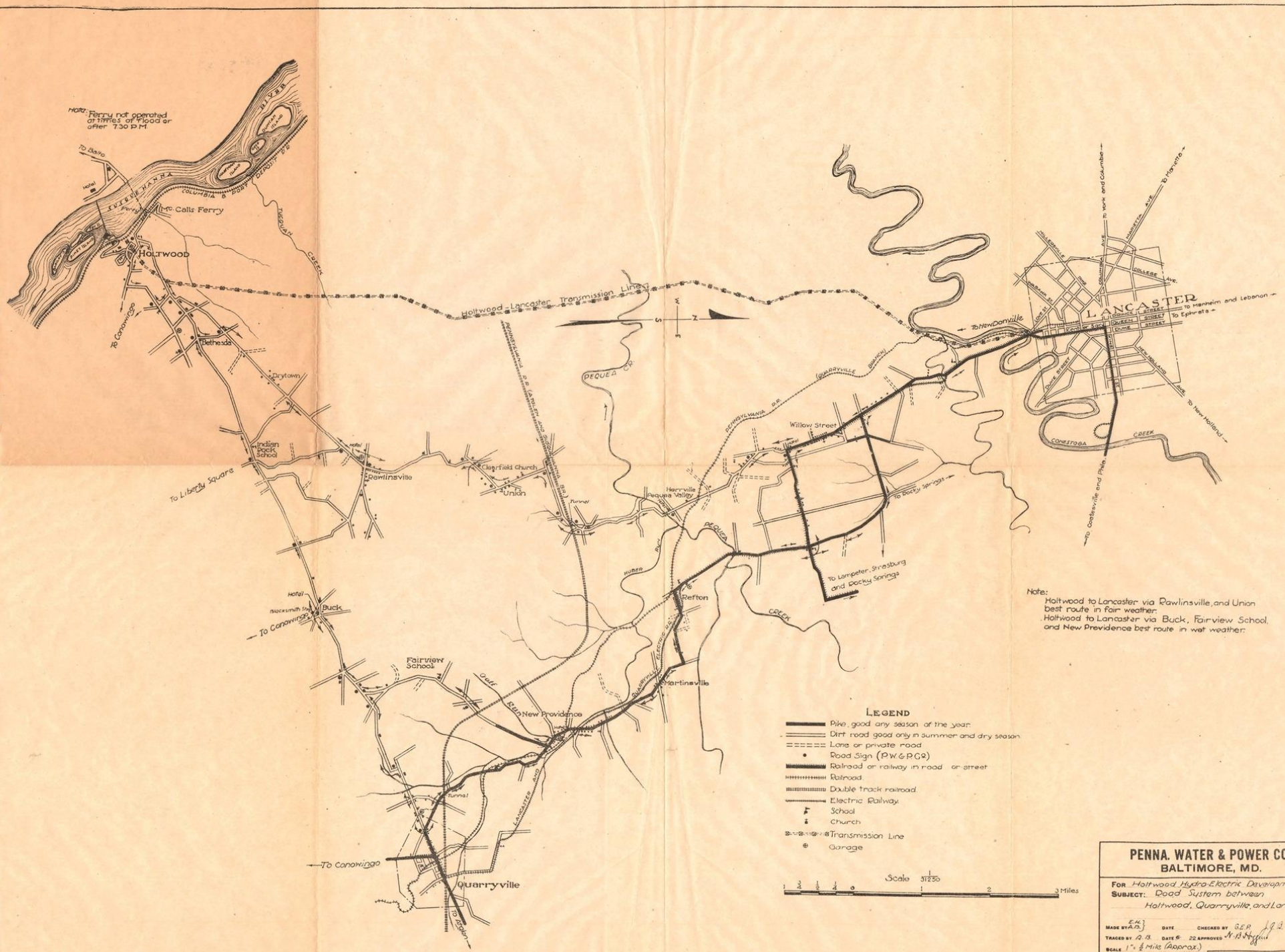
to solve them. It has conducted its operations with benefit alike to its security holders and to the territory it serves; its great plant is relatively safe from hazards and has increased greatly in value; its market has been developed and its future is assured; its management is shown by its record to be able and conservative; and finally, its raw material—water power—will endure as long as the sun shines and water flows.

Chas E. Oakley

PRESIDENT


Note:
Ferry at McCalls Ferry not operated at times of flood or bad ice conditions
Note:
Route through Delta is preferable.
Route through Conowingo is impassable in bad weather.
Ferry at McCalls Ferry not operated at times of flood or bad ice conditions.
Legend
Pike-good any season of year
Dirt-good only in summer and dry season
Road Sign
School
Church
ROAD MAP
BALTIMORE TO HOLTWOOD
Scale 1" = 1 mile
BALTIMORE CITY
BALTIMORE COUNTY
HARFORD COUNTY
CECIL COUNTY
LANCASTER COUNTY
SUSQUEHANNA RIVER
TOWSON
LOCH RAVEN
LONG GREEN PATROL STATION
ROSSVILLE PATROL STATION
JARRETTSVILLE PATROL STATION
MUDDY CREEK PATROL STATION
BELAIR
HOLTWOOD
CONOWINGO
QUARRYVILLE
410-A-2877
410-A-2877

Holtwood, Quarryville and Lancaster Road Map



PENNA. WATER & POWER CO.
BALTIMORE, MD.

FOR Holtwood Hydro-Electric Development
SUBJECT: Road System between Holtwood, Quarryville, and Lancaster

MADE BY E.K. A.B. DATE CHECKED BY G.E.P. J.G.D. DATE 5-1922
TRACED BY A.B. DATE 6-22 APPROVED M.B. Hoggan DATE 6-20-22
SCALE 1" = 1 Mile (Approx.)

DWG. No. 100-A-3405